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Separating the influences of prereading skills on early word and nonword reading

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ABSTRACT

The essential first step for a beginning reader is to learn to match printed forms to phonological representations. For a new word, this is an effortful process where each grapheme must be translated individually (serial decoding). The role of phonological awareness in developing a decoding strategy is well known. We examined whether beginning readers recruit different skills depending on the nature of the words being read (familiar words vs. nonwords). Print knowledge, phoneme and rhyme awareness, rapid automatized naming (RAN), phonological short-term memory (STM), nonverbal reasoning, vocabulary, auditory skills, and visual attention were measured in 392 prereaders 4 and 5 years of age. Word and nonword reading were measured 9 months later. We used structural equation modeling to examine the skills–reading relationship and modeled correlations between our two reading outcomes and among all prereading skills. We found that a broad range of skills were associated with reading outcomes: early print knowledge, phonological STM, phoneme awareness and RAN. Whereas all of these skills were directly predictive of nonword reading, early print knowledge was the only direct predictor of word reading. Our findings suggest that beginning readers draw most heavily on their existing print knowledge to read familiar words.

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Introduction

The fundamental challenge for a beginning reader is to convert the graphemic representation of a word into a phonologically based representation. This enables access to the reader's existing knowledge of that word, which has been gained through the process of oral language acquisition (see Hoover & Tunmer, 1993, for a discussion). This process of matching print to phonological representations is termed *decoding.* A more precise definition of decoding was provided by Ehri (e.g., 1998), who distinguished between basic decoding (graphemes are translated one by one into phonemes and then blended together to read a word) and more advanced decoding (pronouncing and blending familiar spelling patterns). Although basic decoding is a slow and effortful process, each successfully decoded word provides an opportunity for a reader to develop orthographic representations (self-teaching through phonological recoding; Share, 1995). According to many theorists (Ehri, 1998; Grainger, Lété, Bertand, Dufau, & Ziegler, 2012; Share, 1995), it is only through the process of recoding a word into its phonological form that a child will eventually develop coarse-grained orthographic representations that enable fast access from print to reading.

There is general agreement that the most effective teaching strategies focus on explicitly training children to decode letters and letter combinations into sounds (termed *phonics methods*; Rose, 2006). Despite this consensus, children in many English-speaking countries learn to read through a combination of phonics methods and whole-word recognition of frequent words by sight (e.g., see Coltheart & Prior, 2007; Ellefson, Treiman, & Kessler, 2009; Masterson, Stuart, Dixon, & Lovejoy, 2010). The rationale for a mixed approach is that many of the most frequent words in the English written language are not decodable or are difficult to decode using the limited grapheme–phoneme knowledge of beginning readers. This makes whole-word representations useful during the early stages of learning to read even though graphemic representations have the highest utility in the longer term (Vousden, Ellefson, Solity, & Chater, 2011). The first year of formal schooling in English, therefore, is an interesting period when children are developing an alphabetic principle and learning to decode some words while being encouraged to recognize some familiar words by sight. Therefore, we may well expect beginning readers to recruit different skills depending on the demands of the reading task and/or the specific words being read.

There is a huge body of work characterizing the developmental progression from letter-by-letter decoding through to fluent effortless reading (e.g., Ehri, 2008). However, there has been less research examining whether different skills are recruited when reading words that can be recognized by sight versus reading nonwords that must be at least partially decoded. According to Ehri's phase theory (e.g., Ehri, 2008), children move from a reliance on arbitrary visual cues (pre-alphabetic) through to partial knowledge of grapheme–phoneme correspondences, enabling partial decoding of words (e.g., using initial and final letters, partial alphabetic). Children transition to the full alphabetic phase when they know the major grapheme–phoneme correspondences and can match up the graphemes in an entire word into phonemes, enabling the word to be fully decoded and pronounced. Importantly, Ehri conceptualized her developmental theory as a succession of qualitatively distinct "phases" rather than rigid stages. In other words, it is not necessary for a child to master one phase before moving on to the next. Instead, a child may continue to use basic pre- or partial alphabetic strategies to read some words even though the child has enough alphabetic understanding to attempt a decoding strategy.

Evidence concerning the skills that predict early reading

The purest measure of a child's decoding skill is obviously gained from nonword reading tests (e.g., see discussion in Hoover & Tunmer, 1993). However, decoding is commonly measured using isolated real words (the vast majority of correlational studies reported in Melby-Lervåg, Lyster, & Hulme's (2012) meta-analysis used single word reading measures). Although arbitrary lists of real words provide no cues to context, they may include highly familiar words that have been taught as whole words in class. The notable exceptions to this are studies that have examined the predictive power of rapid automatized naming (RAN) separately for word and nonword reading (e.g., Compton, 2003; Hudson, Torgesen, Lane, & Turner, 2012; Lervåg, Bråten, & Hulme, 2009; Moll, Fussenegger, Willburger, & Landerl, 2009). These studies are discussed later in the context of our predictions regarding RAN. Below, we review research into predictors of early reading in general before making predictions about whether early word and nonword reading may recruit different skills.

Phonological skills

According to Wagner and Torgesen (1987), phonological processing can be separated into three aspects: the explicit awareness of phonological information in words (e.g., the ability to segment a word into phonemes, termed *phonological awareness*), recoding of this information in a form that can be retrieved in lexical access (termed *phonological access,* commonly measured by RAN), and recoding of this information into a form that can be maintained in working memory (termed *phonological short-term memory*). As discussed in Lonigan (2006), these skills are usually found to represent distinct factors in confirmatory factor analyses, at least for school-age children. In a meta-analytic review, Melby-Lervåg and colleagues (2012) compared the predictive power of two types of phonological awareness (phoneme and rime) along with verbal (phonological) short-term memory (STM). They concluded that phoneme awareness plays the stronger causal role, whereas phonological STM and rime awareness are indirectly related to reading via shared variance with phonemic skills. However, in a recent study not included in this meta-analysis, Martinez Perez, Majerus, and Poncelet (2012) argued that although the processing and storage of verbal information depends directly on phonological processing, serial order information is represented using distinct codes. They measured verbal STM in kindergarten children using tasks that enabled separation of item capacity and order capacity and found that order capacity independently predicted decoding over and above phonological awareness.

Rapid automatized naming

Wagner and Torgesen (1987) conceptualized RAN as one aspect of phonological processing. Although RAN tasks are likely to tap into some of the same processes as phonological awareness tasks, many studies have demonstrated that tasks measuring naming efficiency have an additional independent influence on reading (see Kirby et al., 2010, for a review). However, the processes that drive the RAN–reading relationship remain unclear. Manis, Seidenberg, and Doi (1999) suggested that RAN tasks are good predictors of early reading because they tap into skills associated with learning arbitrary mappings between print and sound. This led to their hypothesis that RAN underpins orthographic knowledge (relevant for word reading), whereas phonological awareness underpins decoding (relevant for nonword reading). In contrast, if RAN primarily taps into phonological processing (e.g., Wagner & Torgesen, 1987), then RAN, along with phonological awareness, should show a stronger influence on nonword reading because nonword reading is the better index of decoding skill. The predictions are less clear if RAN is assumed to provide an index of processing efficiency (e.g., Kail, Hall, & Caskey, 1999). Of course, RAN would have a stronger influence on fluency measures than on accuracy measures, but the predictions about differences between word and nonword reading are not obvious.

A few studies have examined the relationship between RAN and components of reading, but the evidence is mixed. Some studies have found a stronger influence on word reading (e.g., Compton, 2003; Hudson et al., 2012), whereas other studies have found stronger influences of RAN on nonword reading (e.g., Lervåg et al., 2009). Moll and colleagues (2009) found RAN to contribute to both word and nonword reading over and above phonological awareness. They argued against an orthographic processing account of the influence of RAN for two reasons. First, the RAN–word reading relationship is significant even after orthographic spelling was factored out. Second, RAN does not significantly predict word reading after nonword reading was factored out. Thus, the RAN–word reading relationship seems to be driven by the decoding demands of the reading task. Specifically, Moll and colleagues hypothesized that reading demands automaticity of orthography to phonology associations at the letter and letter cluster level. In addition, a meta-analysis by Swanson, Trainin, Necoechea, and Hammill (2003) demonstrated moderate correlations between RAN and different aspects of reading (word and pseudoword), and if anything the correlation with pseudoword reading was slightly higher.

Auditory skills

Finally, although most research into predictors of reading has focused on the cognitive level, other researchers have argued that individual differences in phonological processing are best explained in terms of underlying differences in basic auditory processing (e.g., Banai et al., 2009; Talcott et al., 2002; Tallal, Miller, & Fitch, 1993). Most of this research has been conducted with dyslexic participants, demonstrating either atypical perception of dynamic aspects of auditory stimuli (see Hämäläinen, Salminen, & Leppänen, in press, for a review) or deficits in temporal order judgments with auditory stimuli (see Farmer & Klein, 1995, for a review). However, there is also evidence that individual differences in auditory processing predict reading in typically developing readers (Banai et al., 2009; Talcott et al., 2002).

Visual attention

There is evidence that visual skills influence reading independent of phonological processes. Bosse and Valdois (2009) found that visual attention span (VA) measured in typically developing first-grade children independently predicted their reading development between first and third grades over and above the influence of phonological awareness. VA was predictive of both nonword and irregular word reading in first grade, and whereas the influence on nonword reading declined, the influence on irregular word reading was sustained, suggesting that VA specifically influences orthographic processes. Bosse and Valdois's VA task was designed to tap into the processing of letter information during a single fixation, and the participants were briefly shown a letter string and then asked to name either a full letter string or a cued letter. The authors found that first-grade children attending French primary schools (mean age = 6 years 10 months) could successfully complete this task. Although these children were only in their first year of formal reading instruction, they scored well in standardized tests of reading. Plaza and Cohen (2007) attempted to investigate the influence of VA at the very earliest stages of reading. Because a letter report task would not be reliable when children are acquiring letter sound knowledge, they used a visual search task with nonlinguistic symbols. Plaza and Cohen found independent contributions from visual attention and syllable awareness measured in kindergarten on subsequent reading and spelling performance at Grade 1. The authors argued that during the early stages of reading acquisition, visual discipline (e.g., scanning letters from left to right, visual analysis, visual–spatial organization) is critical to optimize children's viewing position and to enable accurate identification of most of the letters within a word. Thus, visual attention appears to be causally related to the beginning stages of learning to read independent of the important contribution of phonological skills.

The current study

Although previous studies have shown that the skills described above are generally predictive of reading, we do not know whether beginning readers recruit different skills depending on the nature of the words being read. In the current study, we measured these skills in children beginning formal education in the United Kingdom (4 and 5 years of age) and measured reading outcomes (familiar words and nonwords) at the end of the school year. One difficulty with investigating predictors of reading development is that a broad range of intercorrelated skills may be involved. We aimed to address this issue by using structural equation modeling to factor in the correlations between prereading skills and to isolate those skills that directly influence reading.

We were specifically interested in measuring children's basic skills before they had received any formal reading instruction in order to isolate skills that precede reading acquisition. There are two key considerations when working with this age group. First, phonological awareness is notoriously difficult to measure before children have begun to read because the two skills appear to develop reciprocally (Castles & Coltheart, 2004). Nevertheless, many studies have attempted to measure early phonological awareness and observed significant relationships with early reading even from very low initial scores. Although Melby-Lervåg and colleagues (2012) reported that phoneme awareness was the stronger predictor of reading, rhyme awareness appears to develop earlier and may be more feasible to measure in young children (Carroll, Snowling, Hulme, & Stevenson, 2003). Similarly, Carroll and colleagues (2003) found that tasks tapping into implicit sound sensitivity (e.g., matching word pairs) could be performed at a younger age than those requiring an explicit response (e.g., completing the final phoneme of a word). Importantly, Muter, Hulme, Snowling, and Stevenson (2004) found that even though explicit phoneme tasks resulted in very low scores at school entry (e.g., more than half the sample at floor on phoneme deletion), it was still possible to observe significant relationships with early word reading. Thus, it is important to include a range of phonological awareness measures as predictors of early reading even when scores are likely to be low. Second, although children may score at floor on standardized reading tests, they will have been exposed to print, and there is evidence that this experience facilitates the development of early reading (Mol & Bus, 2011). Many studies have successfully measured print recognition in prereaders. The majority of these studies examined early letter knowledge and found that this plays a crucial role in the development of phonological awareness and subsequently reading (see Lonigan, 2006, for a discussion). However, Levy, Gong, Hessels, Evans, and Jared (2006) argued that understanding of print also plays a direct role in reading development. In their sample of English-speaking Canadian children 4 to 7 years of age, they found clear relations between children's print concept and word reading over and above phonological awareness. Importantly, print concepts were also predictive of letter recognition even when word reading was minimal. Although they acknowledged that there is a clear reciprocal relationship between print understanding and reading, Levy and colleagues argued that children's focus on examining and learning letters is the starting point for the development of orthographic knowledge. Given these findings, we anticipate that early knowledge of print will be strongly related to phonological awareness and may also independently predict reading in addition to phonological awareness. A key novel question we address is whether the relative influences of print knowledge and phonological awareness depend on the nature of the task. We anticipate that familiar word reading will tap orthographic knowledge more strongly, whereas nonword reading will provide a purer measure of decoding skill. Thus, we may find a stronger influence of print knowledge on word reading along with a stronger influence of phonological awareness on nonword reading.

More generally, in relation to the predictors of reading we discussed above, we would predict that phoneme awareness should certainly predict nonword reading and may be important for both aspects of reading (consistent with Melby-Lervåg, Lyster, & Hulme, 2012). Print knowledge should certainly predict word reading (consistent with Levy et al., 2006) and is likely to be important for both aspects of reading (because knowledge of letter sounds is fundamental to nonword reading). RAN is expected to have a direct influence, but its relative importance for word and nonword reading is not obvious. Although Manis and colleagues (1999) would predict the influence of RAN to be strongest on word reading, more recent evidence has not provided clear support for this hypothesis. Other measures related to phonological processing are likely to have a greater influence on nonword reading than on word reading because of their role in supporting a decoding strategy (e.g., phonological STM, rhyme awareness, auditory skills). Finally, the predictions for visual attention are less clear because attention to fine-grained visual features is important for both types of reading. Although Bosse and Valdois (2009) hypothesized that VA has a long-term influence on orthographic processing, during the earliest stages of reading it is arguably the serial decoding strategy required for nonword reading that poses greater demands on visual control (e.g., Plaza & Cohen, 2007).

Method

Participants

We collected data from four cohorts of children beginning their reception year, the first year of compulsory schooling in the United Kingdom (mean age = 4 years 6 months), in three primary schools in a large town in Worcestershire. The schools had intakes of predominantly white British pupils of lower than average socioeconomic status who began school with slightly below average attainments (as determined by the U.K. Office for Standards in Education, Children's Services and Skills). Teachers used a broad reading program that included phonological awareness, phonics (decoding strategies), and recognition of high-frequency words by sight.

Of the 455 children registered in the classes, 11 were excluded prior to data collection (due to assessment of learning difficulties, English as an additional language, reluctance to take part, or parental opt-out). A further 52 children were excluded during the study when their school changed head teacher, who opted to discontinue. Data from the remaining 392 children were included in our analyses. Of these children, 44 dropped out of the study before the follow-up session because they moved to different schools, leaving 348 children at follow-up (mean age = 5 years 2 months). Some of these children opted out of some tests, so the *n* fluctuates slightly across measures. In addition, our auditory temporal processing measure involved a training phase (auditory training), and only children who passed this phase undertook the main task, resulting in a smaller *n* for the auditory temporal processing measure.

Assessments

Children were tested individually in their schools. The baseline tests were conducted early in their first term in five or six sessions of up to 20 min (a session was terminated if the child showed signs of reluctance or fatigue). Tasks that were considered to be easier and more enjoyable (verbal and nonverbal reasoning and motor tasks) were conducted in the first session(s), and tasks that were more challenging (phonological and reading tasks) were conducted in the final session(s). The follow-up tests were conducted at the end of the school year in one or two sessions of up to 20 min duration (with word reading and letter sound tasks administered prior to nonword reading tasks).

Baseline measures

Baseline print knowledge. We were specifically interested in measuring children's basic skills before they had received any formal reading instruction. As we discussed above, even prereaders are likely to recognize some print (i.e., letters, digits, and common words). Letter knowledge was measured by presenting each child with a list of all 26 letters in order of decreasing frequency in written English (Vousden, 2008). The child was asked to say the sound of each letter, and the score was the total number of letters identified correctly by their sound (note that children in the United Kingdom are taught letter sounds before letter names; see Ellefson et al., 2009). Because children may learn to recognize digits before words, we also administered the Dyslexia Early Screening Test digit-naming task (Nicolson & Fawcett, 1996). The child's score was the total number of digits identified correctly over 7 test items.

We confirmed that children in our sample were at a prereading stage at baseline using the British Abilities Scales word reading test (Elliott, Murray, & Pearson, 1983). More than 80% of the sample did not read any words correctly, so this measure was not analyzed further. We measured children's passage reading using the New Macmillan Reading Analysis passage reading test (Vincent & De la Mare, 1985). Again, more than 80% of the sample did not read any words correctly, so this measure was not analyzed further. We also assessed children's recognition of common words (hereafter *sight words*) using a list of the 100 most frequent words in written English. The words were listed in order of difficulty based on their word length and frequency in English written language (Vousden, 2008). All children were asked to attempt the first 16 words, and after this the test was terminated after five consecutive errors. The child's score was the total number of words read correctly. Scores were above floor on baseline sight words but were very low. Our main model did not include sight words (Fig. 1), but we checked whether our pattern of results did not change when this measure was included (see Results).

Phonological awareness. We anticipated scores on phonological awareness tasks to be low, so we focused on measures most feasible for this age group: two tasks tapping into children's sensitivity to rhyme, one task tapping into children's sensitivity of phonemes, and one task requiring an explicit verbal response but only to isolate the first sound (rather than a classic "deletion" task that has been shown to be very difficult for this age group; Muter et al., 2004).

Rhyme awareness: In the Phonological Abilities Test rhyme detection task (Muter, Hulme, & Snowling, 1997), the experimenter pointed to a target picture, followed by pictures of three choices underneath, saying their names out loud (e.g., "This is a picture of a boat. Which of these—foot, bike, or

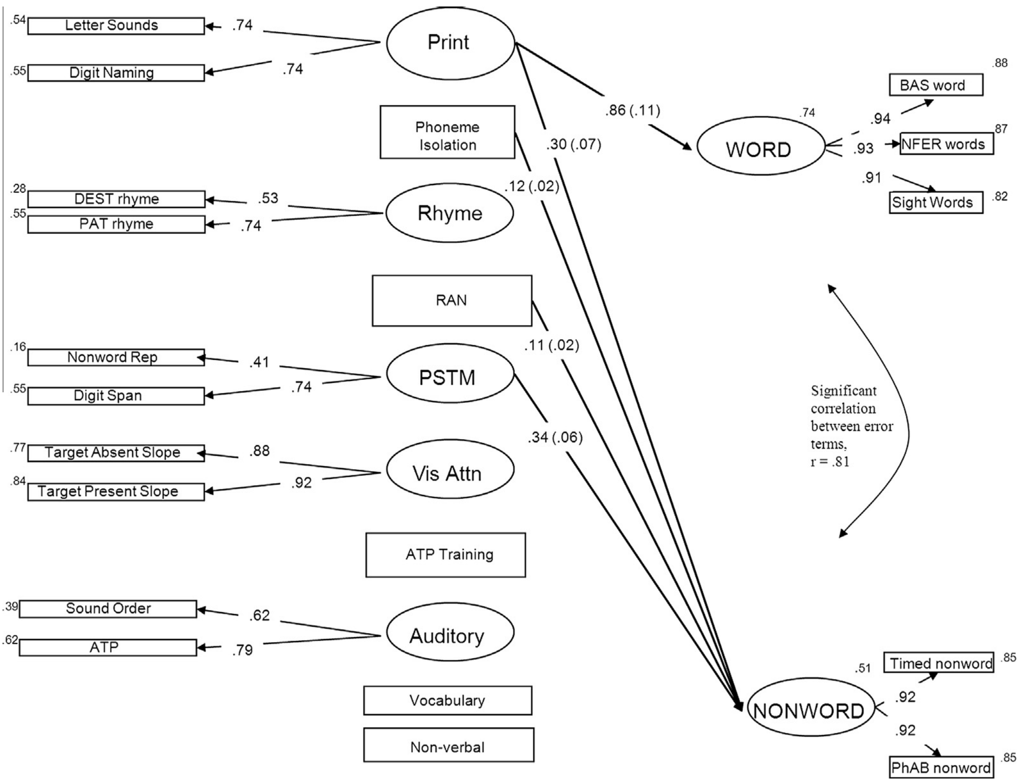

Fig. 1. Structural equation model of the relationships between baseline skills and outcomes. Factor loadings are represented by single-headed arrows with β values shown (all *ps* < .001). Significant structural coefficients (β) are shown as solid lines, and standard errors are indicated in parentheses (all *ps* < .02). Final model: $\chi^2(124) = 187.54$, *NFI* = .95, *CFI* = .98, parsimony comparative fit index (*PCFI*) = .58, *RMSEA* = .036, 0.025–0.046. Squared multiple correlations (R^2) are given at the far left and far right. All correlations between baseline factors are modeled (see Table 2). PSTM, phonological short-term memory; BAS word, British Ability Scales word reading test; NFER words, New Macmillan Reading Analysis passage reading test; PhAB nonword, Phonological Assessment Battery nonword reading test.

coat—rhymes with boat?”). The child’s score was the total number of correct rhymes identified over 10 trials. In the Dyslexia Early Screening Test rhyme detection task (Nicolson & Fawcett, 1996), pairs of words were pronounced by the experimenter without pictures, and the child responded “yes” if the two words rhymed and “no” if they did not rhyme (e.g., in “leg, hen,” the correct response was “no”). The child’s score was the total number of correct responses over 8 trials.

Phoneme awareness. In the Dyslexia Early Screening Test phonological discrimination task, the child was asked whether two words that differed by one phoneme were the same or different (e.g., in “bad, dad,” the correct response was “different”). The child’s score was the total number of correct responses over 9 trials. In the first letter sound test (hereafter *phoneme isolation* of the Dyslexia Early Screening Test), the child was asked to say the first sound of a word (e.g., in “dog,” the correct response was “d”). The child’s score was the total number of sounds identified correctly over 5 trials.

Rapid automatized naming. We used the Dyslexia Early Screening Test rapid picture-naming task (Nicolson & Fawcett, 1996) in which the child was asked to name a series of familiar objects as fast as possible. The child’s score was the time taken to name a list of 40 pictures plus 5 seconds for each error made.

Phonological short-term memory. In the Dyslexia Early Screening Test digit span task (Nicolson & Fawcett, 1996), the child heard strings of numbers presented from a cassette recording and was asked to repeat them back. The child's score was the length of the longest number string repeated back correctly. We also devised a nonword repetition test in which the child was presented with a cassette recording of the nonwords from the Phonological Assessment Battery nonword reading task (Frederickson, Frith, & Reason, 1997) and was asked to repeat back each word in turn. The child's score was the total number of words repeated back correctly over 20 trials (10 one-syllable words and 10 two-syllable words).

Auditory processing. Two tasks were used to measure children's auditory processing. First, in the Dyslexia Early Screening Test sound order task (Nicolson & Fawcett, 1996), the child was presented with two sounds on a cassette recording: a duck's "quack" and a mouse's "squeak." For each pair, the child was asked which animal made the first sound (e.g., in "squeak, quack," the correct response was "mouse"), and the score was the number identified correctly over 16 trials. Second, we created an auditory processing task based on Tallal's (1980) task in which children were presented with computer-generated complex tones composed of frequencies within the speech range. Children learned to associate two buttons with two sounds and then played back sequences of the sounds using the buttons. We piloted our version with 4-year-olds to ensure that the task was appropriate. Our task differed from Tallal's task in only two respects: we used tones that differed more dramatically in pitch than those used by Tallal (one tone was very low [fundamental = 300 Hz] and one was very high [1000 Hz]), and children heard the tones when they pressed the buttons (Tallal did not give her participants this feedback). The task was divided into two phases: a training phase and an auditory temporal processing phase. In the training phase, the child learned to associate the tones with buttons and then was given an auditory discrimination test. In the auditory discrimination test, the child repeated back each tone one at a time until he or she achieved 12 consecutive correct responses (up to a maximum of 60 trials). The child's auditory discrimination score was the proportion of correct responses over the total number of trials completed (retained as an independent observed variable in our model, "auditory training"). In the auditory temporal processing phase, the child was trained to repeat back sequences of sounds and was then given 24 test trials consisting of 4 trials of each combination of sounds at six different interstimulus intervals: 8, 15, 30, 60, 150, and 305 ms. The child's auditory temporal processing score was the total number of trials in which the child repeated back the correct sequence.

Visual attention. We created a visual search task suitable for prereaders using nonlinguistic symbols similar to the task used by Plaza and Cohen (2007). Our visual attention task was borrowed from the conjunction search task designed by Gerhardstein and Rovee-Collier (2002) for very young children. In this task, the child was shown a target dinosaur and was given two practice sessions using a 6×4 array that included 2 types of distracter dinosaur with a target present on 50% of trials. The child pressed a button with a picture of the dinosaur if it was present and pressed a button with a picture of the dinosaur hidden under an "X" if it was absent. In the first practice session, the target dinosaur "wobbled" from side to side. Once the child had made 6 correct responses in a row, he or she was given a second practice session in which the target was still. Once the child achieved 6 correct trials in a row, he or she proceeded to a test of 32 target-present trials (2, 4, 8, or 12 distracters plus the target positioned randomly in a 6×4 array) and 32 target-absent trials (3, 5, 9, or 13 distracters). Incorrect responses were removed from each child's data, and the average response time per distracter (RT slope) was calculated for both target-present and target-absent trials.

Vocabulary and nonverbal reasoning. The British Picture Vocabulary Scale (Dunn, Dunn, Whetton, & Burley, 1997), a receptive vocabulary test, was used as a measure of vocabulary. Nonverbal reasoning was measured using Raven's Coloured Progressive Matrices pasted onto wooden blocks (Raven, Raven, & Court, 1993).

Additional measures. We also measured balance, motor skills, and rate of speech production in the original study, but we found that these skills were not well correlated with our other baseline measures or with reading outcomes. Because these skills are unlikely to be causally related to reading (e.g., Parrila, Kirby, & McQuarrie, 2004; Rochelle & Talcott, 2006), these measures were removed from the analyses presented below.

Outcome measures (taken at follow-up)

Nonword reading. First, each child was asked to read as many nonwords as he or she could in 30 s from a list of 25 nonwords in order of increasing difficulty (the first 5 items were three-letter words). The child was given one demonstration and 3 practice items before the test. Second, the child was given the Phonological Assessment Battery nonword reading task (Frederickson et al., 1997). This task was untimed, and the score was the total number of nonwords read correctly out of 20. If the child scored 0 in the timed nonword test, the untimed nonword reading task was not administered and the child's score was assumed to be 0. Both nonword reading tasks began with a block of 5 single-syllable three-letter words (e.g., "gep," "pim"). The timed nonword task remained one syllable throughout (progressing to consonant blends, e.g., "bamp"). The Phonological Assessment Battery nonword task continued to a block of 5 one-syllable words with a digraph (e.g., "chog"), followed by a final block of 10 two-syllable words. Both tasks used similarly large font and well-spaced words displayed on a sheet of A4 paper.

Single word and passage reading. Single word reading was measured using the British Abilities Scales word reading test (Elliott et al., 1983) as at baseline. Passage reading was measured using the New Macmillan Reading Analysis passage reading test (Vincent & De la Mare, 1985). The child's score was the absolute number of words read. We also assessed comprehension, but these scores were not used because text reading accuracy was too poor for these to be interpretable. Sight word accuracy was measured using the same sight word test used at baseline, although at follow-up we also timed how many words the child was able to read correctly in 30 s to gain a fluency measure. Our main model (Fig. 1) included the accuracy measure, but we checked whether our pattern of results remained the same when sight word fluency was included instead (providing a fluency measure for both word and nonword reading outcomes). All word reading tasks began with single-syllable words (first block in British Abilities Scales word reading test and sight word reading as well as first passage in passage reading test) and used similarly large font and well-spaced words displayed on a sheet of A4 paper.

Additional measures. A measure of letter knowledge was also taken at follow-up. This measure is not included in the current article because the majority of children knew most of their letter sounds by the end of their first year of school. In contrast, our reading tasks resulted in a good distribution of scores and were considered to be more informative measures of literacy outcomes.

Results

Below, we examine our baseline and outcome measures and consider our strategy for missing scores. We then describe preliminary analyses of the baseline and outcome data, which enable us to make inferences about underlying factor structure to guide the formation of our models. We complete this section with our structural equation models of the relationship between baseline skills and outcomes.

Examination of baseline and outcome scores

Means and standard deviations for each measure are reported in Table 1 together with internal consistency, kurtosis, and skewness estimates. Scores were low for all print measures at baseline, although children performed better on letters and numbers than on words. As expected, scores were very low for our phonological awareness tasks, with approximately half of the sample performing at floor or chance. Nevertheless, previous research has shown that even when very low phonological awareness scores are achieved, these measures are informative in predicting later reading (e.g., Muter et al., 2004). In fact, all of our measures of phonological awareness were significantly correlated with

Table 1
Descriptive statistics and reliabilities for all baseline and outcome measures.

Baseline measure	*n*	Min	Max	*p* at floor or chance (%)	*M*	*SD*	Skew	Kurtosis	Cronbach's alpha
Letter sound knowledge	387	0	26	19	4.71	5.51	1.01[b]	0.55	.92
Sight words	380	0	100	37	1.93	5.81	−0.19[da]	−1.57	.94
Digit naming	387	0	7	15	3.69	2.61	0.01	−1.48	.89
PAT rhyme	386	0	10	52	4.26	3.04	0.64	−0.79	.82
DEST rhyme	379	0	8	66	3.89	2.03	−0.43	−0.07	.40
Phonological discrimination	377	0	9	30	5.55	1.79	−0.02	−0.17	.44
Phoneme isolation	375	0	5	67	1.14	1.85	1.28	−0.06	.93
RAN (s)	375	34.14	230.00		86.61	28.74	−0.80[ab]	1.15	.75
Nonword repetition	376	0	20	1	9.81	3.71	−0.18	−0.22	.71
Digit span	377	0	7	10	2.81	1.62	0.10	−0.53	.69
Sound order	379	0	16	35	9.77	2.88	−0.04	0.45	.69
Auditory training	370	38.33	100	6	83.52	16.03	−0.98	−0.12	.92
Auditory temporal processing	247	2	24	13	12.80	4.94	−0.07	−0.76	.76
Visual attention (target-absent slope)	375	183.91	1975.59		664.15	239.89	−0.17[ac]	0.61	
Visual attention (target-present slope)	375	245.58	2772.27		710.84	327.51	−0.64[ac]	0.64	
Vocabulary	390	12	89		45.08	11.20	0.32	1.10	.83
Nonverbal	384	5	29		14.63	4.48	0.51	0.02	.79
Outcome measure									
BAS word reading	348	0	70	15	9.31	10.95	−0.25[c]	−0.71	.93
Passage reading (words read)	346	0	460	14	29.31	52.72	−0.11[c]	−0.78	.89
Sight word accuracy	338	0	100	4	21.29	25.11	0.98[b]	0.25	.95
Sight word fluency	320	0	31	6	7.79	6.74	1.07	0.54	.87
Nonword fluency	345	0	21	39	2.32	2.98	0.96[b]	0.51	.85
PhAB nonword	346	0	18	35	3.13	3.26	0.39[b]	−0.73	.75

Note: Means and standard deviations for raw scores are shown. Visual attention slopes are shown as milliseconds (ms) per distracter. Prior to analysis, response time (RT) scores were reversed to follow the same directionality as the other measures. Skew and kurtosis of final scores used in analyses are presented using the following transformations when necessary: *a* = reversal of distribution; *b* = square root; *c* = natural log; *d* = reciprocal. Cronbach's alpha was calculated using raw data from 10% of the sample as a measure of internal consistency. DEST rhyme, Dyslexia Early Screening Test rhyme; PAT rhyme, Phonological Abilities Test rhyme; BAS word reading, British Ability Scales word reading test; PhAB nonword, Phonological Assessment Battery nonword reading test.

reading outcomes, with phoneme isolation showing the strongest correlations (see Table 3 below). The Dyslexia Early Screening Test rhyme and phonological discrimination tasks showed low internal consistency (Table 1), although test–retest reliability is higher (.84 for rhyme and .68 for phonological discrimination; Nicolson & Fawcett, 2004). Other measures show relatively good distributions and internal consistency.

For sight word reading at follow-up, we took two measures: fluency and accuracy. Our accuracy measure showed a better distribution of scores and was more strongly correlated with our other reading measures (Table 2), so this was used in our main model (Fig. 1). However, we checked whether the pattern of results did not change when a fluency measure was included for both word and nonword reading outcomes (see below).

As shown in Table 1, there are missing data for some tasks. Missing data may be missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR) (see Jeličić, Phelps, & Lerner, 2009). Data are considered MCAR if the probability of an observation being missing does not depend on either observed or unobserved measurements (i.e., losing data through a decision or an event unrelated to the participant). To be MAR, the probability of an observation being missing must not depend on the unobserved data but can depend on observed data (e.g., removing a participant's data on one measure due to a predefined criterion on another measure). Much of our missing data match this second definition. For example, children had missing data on the auditory temporal processing task if they failed to reach criterion on the auditory discrimination test. Other missing data were caused by some children refusing to participate in some sessions, and refusal may be related to performance on preceding tasks (i.e., observed information). Nevertheless, it is possible that a factor that we did not measure (e.g., shyness) also contributed. We also missed data for children who left the study prior to the follow-up session (44/392 children; 11%). All measures at baseline showed a nonsignificant difference between children with and without outcome data ($p > .05$). To confirm that our findings were consistent across these groups, we used multiple group analyses to compare models with and without these children (see "Alternative models" section below). All other missing outcome data (child refusal/absence) were MCAR, Little's MCAR test, $\chi^2(9) = 7.23$, $p = .61$.

Kaiser–Mayer–Olkin's measure of sampling adequacy (.87) and Bartlett's test of sphericity, $\chi^2(210) = 2220.84$, $p < .001$, indicated that this correlation matrix was suitable for factor analysis. All confirmatory factor analyses and structural equation modeling were conducted using AMOS 16.0 (Arbuckle, 2007), accounting for missing data using maximum likelihood estimation (considered to be a good method for addressing MAR and MCAR data; Jeličić et al., 2009).

Preliminary analyses of baseline data

We built a confirmatory factor analysis model with five factors (print, rhyme, auditory, visual attention, and phonological STM) and separate observed variables for phoneme isolation, RAN, nonverbal reasoning, vocabulary, and auditory training, $\chi^2(50) = 72.79$, normed fit index (NFI) = .96, comparative fit index (CFI) = .99, root mean square error of approximation ($RMSEA$) = .034, .014–.050 (model shown at left of Fig. 1). Our main model did not include baseline sight words. Although this measure loaded well from the print factor, it would cause a bias in our model. Specifically, any predictive power of print to word reading could be driven by the presence of an autoregressor, and we had no equivalent autoregressor for nonword reading for comparison. Nevertheless, we confirmed that a good fit was gained when sight words was included as an indicator of print, $\chi^2(64) = 99.34$, NFI = .94,

Table 2
Correlations between word and nonword reading outcome measures.

	BAS reading	Passage reading	Sight word accuracy	Sight word fluency	Nonword fluency
Passage reading	.89				
Sight word accuracy	.83	.84			
Sight word fluency	*.74*	*.78*	*.85*		
Nonword fluency	.71	.71	.76	*.67*	
PhAB nonword	.73	.72	.76	*.65*	.85

Note: Correlations with sight word fluency are shown in italics because this measure was not included in the main analyses.

CFI = .98, *RMSEA* = .038, .022–.052, and we tested outcome models for both these baseline structures (see "Alternative models" section below). We could not include a "phoneme awareness" factor because phoneme isolation and phonological discrimination correlated at only .26. Phoneme isolation correlated strongly with other related baseline measures and with reading outcomes, so it was retained as an independent observed variable. In contrast, phonological discrimination showed generally low correlations and was removed from all further analyses. The implied correlations between the variables in our final structural equation model (Table 3) indicate that print, phoneme isolation, phonological STM, and auditory skills were highly associated.

Preliminary analyses of outcome data

Scores for the reading tests conducted at follow-up are reported in Table 1, and correlations between them are reported in Table 2. Sight word accuracy showed a better distribution of scores and was more strongly correlated with other word reading measures, so it was used in the following analyses instead of sight word fluency. Apart from sight word fluency, correlations between all word reading and nonword reading measures were high (all > .70), but the highest correlations were within the three word reading measures and within the two nonword reading measures (all > .80). Although an initial principal axis factoring analysis suggested that either a one- or two-factor solution may be appropriate, a one-factor confirmatory factor analysis model, $\chi^2(5) = 171.81$, showed a significantly worse fit than a two-factor model, $\chi^2(4) = 30.73$. Thus, although these two factors correlated highly in our final model (Fig. 1), they were separable.

Structural equation models of relationship between baseline skills and reading outcomes

We built a structural equation model by combining the baseline and outcome factor structures described above. As shown in Fig. 1, we found a very strong direct influence of print on word reading,

Table 3
Implied correlations between baseline observed and latent variables and word and nonword reading outcomes in model (Fig. 1).

	Pri	LS	DN	PI	**Rhy**	Drh	Prh	Ra	**PM**	Nr	DS	**VA**	Tab	Tpr	Atr	**Aud**	SO	ATP	Voc	NV	**WD**
LS	.74																				
DN	.74	.54																			
PI	.63	.46	.46																		
Rhy	.51	.38	.38	.51																	
Drh	.27	.20	.20	.27	.53																
Prh	.38	.28	.28	.38	.74	.39															
Ra	.47	.35	.35	.24	.24	.13	.18														
PM	.70	.51	.52	.52	.52	.27	.39	.33													
Nr	.28	.21	.21	.21	.21	.11	.16	.14	.41												
DS	.52	.38	.38	.39	.38	.20	.29	.25	.74	.30											
VA	.39	.29	.29	.17	.20	.10	.15	.41	.26	.11	.20										
Tab	.34	.25	.25	.15	.17	.09	.13	.36	.23	.09	.17	.88									
Tpr	.36	.26	.26	.16	.18	.10	.13	.37	.24	.10	.18	.92	.80								
Atr	.31	.23	.23	.15	.24	.12	.18	.31	.37	.15	.27	.18	.16	.17							
Aud	.76	.56	.56	.49	.52	.27	.39	.42	.71	.29	.53	.39	.34	.36	.43						
SO	.48	.35	.35	.30	.32	.17	.24	.26	.44	.18	.33	.24	.21	.22	.27	.62					
ATP	.60	.44	.44	.38	.41	.21	.30	.33	.56	.23	.42	.31	.27	.28	.34	.79	.49				
Voc	.46	.34	.34	.40	.46	.24	.34	.22	.49	.20	.36	.30	.26	.27	.20	.47	.29	.37			
NV	.36	.26	.26	.26	.36	.19	.27	.14	.47	.19	.35	.18	.16	.17	.28	.37	.23	.29	.33		
WD	.86	.63	.64	.54	.44	.23	.33	.41	.60	.24	.44	.33	.29	.31	.27	.66	.41	.52	.40	.31	
NW	.66	.48	.49	.51	.41	.22	.31	.39	.64	.26	.47	.27	.24	.25	.27	.57	.36	.45	.37	.31	.85

Note: Latent factors are shown in bold. Pri, print factor; LS, letter sound knowledge; DN, digit naming; PI, phoneme isolation; Rhy, rhyme factor; Drh, Dyslexia Early Screening Test rhyme; Prh, Phonological Abilities Test rhyme; Ra, RAN; PM, phonological STM factor; Nr, nonword repetition; DS, digit span; VA, visual attention factor; Tab, target-absent visual search slope; Tpr, target-present visual search slope; Atr, auditory training; Aud, auditory factor; SO, sound order; ATP, auditory temporal processing; Voc, vocabulary; NV, nonverbal reasoning; WD, word reading outcome factor; NW, nonword reading outcome factor.

moderate influences of print and phonological STM on nonword reading, and small additional influences of phoneme isolation and RAN on nonword reading. Table 3 shows the implied correlations between all measures and latent variables in our model. The clearest pattern in these bivariate correlations is the very high association between early print knowledge and word reading. Phoneme isolation and phonological STM were also strongly associated with print and with word reading outcomes. However, our model shows that when print was factored out, these other skills no longer directly contributed to word reading even though they were highly associated. Print, phonological STM, and phoneme isolation were also strongly associated with nonword reading, but the correlations were of a similar size and all three skills contributed independently to nonword reading outcomes. RAN was associated with print and with both word and nonword reading outcomes. Fig. 1 shows that RAN had an independent influence on nonword reading, but the influence on word reading was not significant after accounting for print. Overall, it is clear that the greatest contribution to word reading was from print. Although other skills were highly associated with print, once the aspects of these skills that relate to print were factored out, no direct relationship with word reading remained. In contrast, for nonword reading, other aspects of phonological STM, phoneme isolation, and RAN were directly predictive over and above print.

Alternative models

First, to confirm that the regression weights for word and nonword reading were significantly different, we built a model in which the structural coefficients from print, phonological STM, phoneme isolation, and RAN to outcomes were constrained to be equal for word and nonword reading. This model was a significantly worse fit than one in which all of these links were modeled but allowed to vary, $\chi^2(4) = 244.25$.

Second, because the model in Fig. 1 did not include a baseline measure of word recognition, we checked whether the same pattern of results was achieved when an autoregressor (sight words) was included as an indicator on the print factor, $\chi^2(143) = 227.22$, *NFI* = .94, *CFI* = .98, *RMSEA* = .039, .029–.048. As in our main model (Fig. 1), print was the only significant predictor of word reading ($\beta = .86$), and print ($\beta = .33$), phonological STM ($\beta = .31$), phoneme isolation ($\beta = .12$), and RAN ($\beta = .10$) were all significant predictors of nonword reading.

Third, the model in Fig. 1 was unbalanced by the existence of a fluency measure for nonword reading but not for word reading. The loadings from nonword reading to the fluency and accuracy indicators were equal, making it unlikely that our findings were driven by the fluency indicator. Nevertheless, we checked whether the same pattern of results was achieved when a fluency measure was also included as an indicator of word reading. Specifically, sight word reading accuracy was replaced by sight word fluency, $\chi^2(124) = 186.01$, *NFI* = .95, *CFI* = .98, *RMSEA* = .036, .025–.046. As in our main model (Fig. 1), print was the only significant predictor of word reading ($\beta = .85$), and print ($\beta = .30$), phonological STM ($\beta = .33$), phoneme isolation ($\beta = .12$), and RAN ($\beta = .12$) were all significant predictors of nonword reading.

Finally, we conducted a multiple group analysis to compare our final model using the full sample (Fig. 1) with the same model but including only children with follow-up data. We found that all aspects of the final model could be constrained to be invariant across the two groups without a significant decrease in fit: measurement weights, measurement intercepts, structural weights, structural means, structural covariances, structural residuals, and measurement residuals, $\chi^2(102) = 5.14$.

Discussion

We used a structural equation modeling approach to separate influences of prereading skills on early reading at the end of the first year of school. Our study captured an early stage of reading in which the predictors of word and nonword reading are separable. Below, we discuss our findings regarding the relationships between prereading skills before discussing predictors of word and nonword reading.

Relationships between prereading skills

Although children scored at floor on standardized reading tests at baseline, we were able to measure their letter sound knowledge and reading of digits. We were also able to measure sight word recognition, although scores were very low. All three measures loaded well onto our print factor, suggesting that identification of all forms of print tap into similar skills at school entry. Our main model included just letter and digit knowledge as indicators of print (to avoid biasing our print factor by including an autoregressor of word reading). Although it may appear to be surprising that digit and letter sound knowledge load from the same factor, the distinction between letters and digits will not be obvious to a prereader because either task requires matching an arbitrary symbol to the appropriate pronunciation. This factor is likely to reflect the extent to which a child has been exposed to print before school and the child's ability to recall the sounds associated with each printed symbol.

Children also performed poorly on all phonological awareness tasks, but despite low scores these measures were well correlated with later reading (correlations were of a similar size to previous studies, e.g., Muter et al., 2004). This is in line with previous findings that phonological awareness tasks are very challenging for prereaders but are still predictive of later reading. As in Carroll and colleagues (2003), children scored slightly better on our rhyme measures, probably because these tasks tapped into sensitivity rather than explicit awareness and involved larger units. Nevertheless, our measure that elicited the lowest scores (phoneme isolation) showed the highest correlations with print measures at baseline and with reading outcomes. This association suggests that explicit awareness of the sounds in words and knowledge of print develop reciprocally. It is possible that orthographic knowledge was particularly helpful for the phoneme isolation task. If a child were able to imagine the printed word, this would provide an additional route for retrieving the sound of the first letter. Auditory skills were also highly correlated with print knowledge and phonological STM and were moderately correlated with phoneme and rhyme awareness, perhaps because they also tapped into children's ability to judge and/or reproduce the order of sounds (Banai et al., 2009; Talcott et al., 2002; Tallal et al., 1993). Although our auditory measures were highly associated with reading, they did not make a direct contribution after other skills were factored out.

Predictors of word and nonword reading

Although word and nonword reading outcomes were highly correlated, we found them to be separable with a different pattern of predictors. In particular, print knowledge made the only direct contribution to word reading, whereas the following skills all made direct contributions to nonword reading: print knowledge, phonological STM, phoneme isolation, and RAN. The importance of early print knowledge for word reading fits nicely with our predictions, and these findings are discussed in the next section. First, we outline other skills that made additional contributions to reading development in our models.

Consistent with Melby-Lervåg and colleagues (2012), we found that phoneme awareness was highly associated with both word and nonword reading and independently predicted nonword reading. As expected, although our rhyme measures were moderately correlated with reading outcomes, our rhyme factor did not make an independent contribution over and above phoneme awareness. However, inconsistent with Melby-Lervåg and colleagues, we found that phonological STM predicted nonword reading over and above the influence of print and phoneme awareness. This additional contribution may be due to the age group with which we worked. Most studies reviewed by Melby-Lervåg and colleagues were with older children who would have performed well on phoneme awareness tasks. In contrast, phonological STM is arguably a more appropriate measure of phonological skills for prereaders; children readily understand the instructions, and it is possible to gain a good distribution of scores. In addition, success on these tasks may be less reliant on existing orthographic knowledge because explicit segmentation of the phonemes within words is not required (but see Nation & Hulme, 2011, for a contrasting view). Instead, the link from phonological STM to nonword reading may reflect the similar cognitive demands of the two tasks. In particular, both tasks place demands on serial order processing. As described by Martinez Perez and colleagues (2012), early decoding may be especially demanding of serial order processes. Specifically, beginning readers must first translate each grapheme into a corresponding phoneme and then temporarily store this sequence in order while blending the sounds to produce the full phonological form.

The additional independent influence of RAN on nonword reading may reflect the need to complete the translation process efficiently so that the phonological codes can be kept in memory before blending them together to pronounce the word. This explanation is consistent with Moll and colleagues' (2009) hypothesis that the association between RAN and literacy has to do with the automaticity of orthography to phonology associations at the letter and letter cluster levels (see also Kail et al., 1999, for an efficiency account of the RAN–reading relationship). The predictive power of RAN on nonword reading is unlikely to be simply driven by the inclusion of one nonword fluency measure. First, the fluency and accuracy indicators made equal contributions to the nonword latent variable. Second, RAN did not directly predict word reading even when a word reading fluency measure was included as an indicator. Instead, it is likely that nonword reading tasks pose greater demands on efficiency for beginning readers whether fluency or accuracy is the outcome.

Finally, we found no direct influence of visual attention skills on early reading (unlike Plaza & Cohen, 2007, and Bosse & Valdois, 2009), and correlations between visual attention and other baseline factors in our outcome models were fairly low. Nevertheless, it is important to note that our children were approximately 1 year younger than the initial assessment in Plaza and Cohen's (2007) study and were approximately 2 years younger than Bosse and Valdois's (2009) initial assessment. Visual attention skills may play a stronger role when children have become a little more fluent in their decoding (e.g., left to right scanning and maintaining an optimal viewing position may be more relevant when reading longer words or when decoding short words more efficiently).

Influence of early print knowledge on word reading

As we have summarized above, we found differences in the relative importance of prereading skills for early word and nonword reading. In particular, print knowledge was by far the strongest predictor of word reading. This influence was maintained even when the baseline sight word task was removed (leaving only letter and digit measures on this factor). Although print knowledge was also important for nonword reading, this contribution was smaller and apparent alongside direct influences from a broader range of skills. These different patterns of predictors suggest that children may have been relying on different strategies for reading these two types of words. We can be confident that beginning readers will have used serial decoding to successfully read nonwords. In contrast, the strong influence of print on word reading suggests that they may have relied on processes similar to those used in early print recognition. The precise strategy that children were using for reading words is not clear. They may have recognized the words as wholes (e.g., by their overall form or distinctive features akin to the pre-alphabetic phase described in Ehri & Wilce, 1985). However, because their letter sound knowledge was good, it is more likely that they recognized the words based on partial alphabetic knowledge but without sounding them out (e.g., first and/or last letters). This second explanation is consistent with Levy and colleagues' (2006) findings that early experience with print is crucial for the development of orthographic knowledge. Either way, our findings suggest that when children were confronted with familiar words, they relied more on visual recognition of print and less on serial decoding.

The hypothesis that children used a basic print recognition strategy works well for our sample because they were taught to recognize some highly frequent words by sight. The standardized tests of word reading we used began with frequently occurring words, and children should have been familiar with these (see Masterson et al., 2010, for details of high-frequency words taught in U.K. schools). In contrast, children were taught to decode unfamiliar regular words. Thus, it was likely that the children who performed well on our word reading tests recognized the words by sight rather than resorting to slow and effortful decoding. One further point to note is that the stimuli in our word reading tests represent a mixture of regular and irregular words. For example, within the first 10 words of the British Abilities Scales word reading test (Elliott et al., 1983), 5 words are decodable using single letter sounds (''up,'' ''on,'' ''at,'' ''jump,'' and ''box''), one is decodable using simple letter combinations (''fish''), and the others are irregular (''the,'' ''go,'' ''he,'' and ''you''). Similarly, more than half of the words in the New Macmillan Reading Analysis passage reading test (Vincent & De la Mare, 1985) are decodable using single letter sounds, although the sight word reading test has a lower proportion of decodable words (~1/3). Thus, it is striking that even though some of these words could have been decoded using the letter sound knowledge that children had acquired by the end of the first school year, we still observed a distinct pattern of predictors for words versus nonwords.

Predictions for subsequent development

We captured a very early stage of reading, from prereader to beginning reader. At the end of their first year of school, children in our sample were just beginning to use a decoding strategy, successfully reading approximately 3 nonwords on the Phonological Assessment Battery nonword reading task (Frederickson et al., 1997). At the same time, they appeared to rely on basic print recognition processes when reading familiar words, consistent with Ehri's (2008) view that children do not move abruptly from one phase of reading to another.

The pattern of predictors is likely to change as children become more proficient readers. As a child is confronted with a larger number of words, the utility of whole-word representations decreases and instead small units (letters and letter clusters) become more predictive (Vousden et al., 2011). Therefore, we would predict that the influence of phonological skills should initially increase as children rely more heavily on decoding. In the longer term, Grainger and colleagues (2012) would predict that the role of phonological skills then subsequently decreases as exposure to more words enables the development of coarse-grained orthographic representations and faster mappings from print to sound. Specifically, there should be a rapid decrease in the influence of phonological processes as phonological recoding is replaced by automatic translation of orthographic information. Nevertheless, because orthographic information is translated into a sublexical code, phonological influences should still be observed (e.g., masked phonological priming), although these should diminish with increasing reading experience, eventually stabilizing once fluent expert reading has been achieved.

Conclusions and further research

Our research confirms the importance of phonological skills in learning a decoding strategy and provides the first clear evidence of early differences in the pattern of predictors for different types of words. Whereas early print knowledge was the key predictor of familiar word reading, the influence of print knowledge on nonword reading was smaller and apparent alongside direct influences of phonological skills and RAN. It is important to note that we observed this separation during the very first stages of learning to read when children are just beginning to develop decoding strategies. It is likely that the range of phonological skills used in decoding narrows as this task becomes less effortful. On the other hand, children may start to recruit phonological skills more heavily when they are confronted with unfamiliar real words. An important line of inquiry for further research is whether the word reading advantage for children with good print knowledge is sustained as they become more proficient readers. If this appears to be a transitory boost, this could have implications for the optimal balance of sight word knowledge and phonics teaching, in particular, whether training children to recognize familiar words by sight discourages the use of a decoding strategy or whether an early sight vocabulary continues to support growth in word reading.

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